Title:

Development of a multivariable Reproductive Index to assess fertility of dairy cows

Introduction:

Fertility is a critical component of dairy production and failures to attain and maintain pregnancy are major reasons for production losses in dairy herds. Reproductive efficiency is determined by a number of complex cow and environmental factors. Methodologies refining the identification of cows with low and high fertility would be a valuable tool for research in multiple areas, including genetic selection. Therefore, our objective was to develop a Reproductive Index (RI) to predict the probability of a timely pregnancy in a large population of dairy cows.

Materials and methods:

The RI represents a calculated predicted probability that a cow will become pregnant, as a function of the explanatory variables used in a logistic model. Data from a total of 11,733 cows calving in 16 farms located in 4 regions (Northeast, Midwest, Southeast, and Southwest), enrolled at parturition and monitored weekly for reproductive events and health status were available. The final model for RI included the random effect of farm and a complement of significant fixed effects as explanatory variables influencing a pregnancy outcome: 1) incidence of retained placenta; 2) metritis; 3) clinical endometritis; 4) lameness at 35 DIM; 5) resumption of ovulation by 50 DIM; 6) season of calving; and 7) parity number. For instance, assuming that uterine disease, anovulation, and lameness negatively influence the probability of pregnancy, cows affected with those problems will have a low RI, although some will become pregnant. On the other hand, cows without those problems will have a high RI, although some will remain open after 2 AI. The RI was developed as a continuous variable, originated from the probability equation of the logistic regression model, ranging from 0 to 1 that is directly related to the probability of pregnancy: $P(\text{pregnancy}|\alpha,\beta) = e^{\Sigma \beta i Zi + \mu\sigma}/1 + e^{\Sigma \beta i Zi + \mu\sigma}$, where: $P(\text{pregnancy}|\alpha,\beta)$ is the probability that a cow will be pregnant given a set of fixed factors Z_i, the random effect of farm μ, and the set of multiplicative slopes β_i and a scale parameter σ. To assess the model fit and the overall predictability of the final statistical model, receiver operating characteristic curve analyses were performed by using the predicted probability estimates (RI) and the dichotomous variable pregnancy. Multivariate logistic regression was used for testing the correspondence between the resulting RI and real individual fertility data (pregnancy per AI and pregnancy loss between 32 d and 60 d after AI) from this population. To facilitate the analyses, the resulting RI values were categorized as low (LRI) for cows in the lowest quartile (RI <0.26); medium (MRI; 0.26 ≥ RI ≤ 0.39) for cows within the interquartile range, and high (HRI; RI > 0.39) for cows in the top quartile.

Results:

For cows in LRI, MRI, and HRI categories, the proportions of pregnant cows at first AI were 25.5%, 35.7%, and 45.4%, respectively (P < 0.0001). At second AI, the proportions of pregnancy were 29.5%, 38.2%, and 40.9%, respectively (P <0.0001). Pregnancy losses at first AI were 14.3%, 11.2%, and 7.5% for cows in LRI, MRI, and HRI categories, respectively (P <0.0001); at second AI, pregnancy losses were 12.8%, 9.2%, and 5.9%, respectively (P = 0.002). For cows in LRI, MRI, and HRI categories, days open were 150, 133, and 118 d, respectively (P < 0.001). Multivariable logistic regression indicated that cows in the HRI category had 2.30 (95% CI = 2.00 to 2.62) and 1.63 (1.40 to1.91) times greater odds of becoming pregnant at first

and second AI than LRI cows, respectively. Similarly, cows in the LRI category had 1.61 (1.15 to 2.30) and 2.16 (1.37 to 3.41) times greater odds to lose their pregnancy after first and second AI than HRI cows, respectively.

Conclusion: There was a consistent agreement between categories of the predicted RI and the measures of fertility collected from dairy cows. Therefore, it is concluded that the proposed RI is a viable method to refine the allocation of cows into potential low and high fertility populations. This is a viable tool to assist in phenotypic determination for genetic selection purposes.